Caltrans

Widening Existing Bridges

A bridge widening can present a multitude of individual problems during the planning and design stages, during construction, and throughout its existence under traffic. Special attention is required in both design and details of the widening in order to minimize construction and maintenance problems.

Because of the large number of factors to be considered in the widening, the Design Engineer after consultation with a representative of the Seismic Analysis and structural Analysis (SASA) section, shall decide whether a strategy meeting similar to that used for seismic retrofit should be held in order to obtain a consensus agreement on the total effort necessary for the widening. A representative of SASA should be asked to attend the type selection meeting.

When preparing Advanced Planning Studies, General Plan Estimates, etc., for widenings, the District should be informed of the costs to upgrade the existing structure as soon as possible.

1. Information Sources

It is often necessary to obtain a considerable amount of detailed information about a bridge that becomes a candidate for widening prior to deciding how to design the widening.

Some sources which may be utilized are:

a) Preliminary Report, if one is available.
b) Preliminary Investigation. Make special and specific requests to the P.I. Section.
c) Translab Engineering Geology section.
d) Bridge Maintenance. Existing structures are inspected annually and the record of these inspections is available in Bridge Books in the Maintenance Section. A discussion with the Area Maintenance Engineer is often helpful.
e) Construction. Personnel working in the immediate area can obtain on-site data if it is not practical for the designer to visit the site.
f) Design. A field review should be made when the information available is minimal.
g) As-Built microfilms are available for most existing structures.
h) Photo log in Headquarters Traffic. Contains recent photo from driver's view, which will show current approach rail, bridge rail and possible deck overlays.

Supersedes Memo to Designers 9-3 dated March 1979

2. Existing Structures with Substandard Capacity

When an existing structure designed for live loads less than HS 20-44 or a lower seismic capacity becomes a candidate for a widening, Structures Maintenance should be consulted on the condition and the load carrying capacity of the structure. Structure Maintenance will recommend whether the structure should be strengthened to the same capacity as the widening. For seismic loads see Part 7 of this memo.

The following factors will be evaluated in arriving at a recommendation:

a) Only structure on route that restricts permit loading.
b) Physical condition, operating characteristics and remaining service life of the structure.
c) Cost of strengthening.
d) Traffic handling during construction.
e) Other site-specific conditions.
f) Width of widening.
g) Application of engineering judgement.
h) Seismic condition of structure.

3. Handling of Traffic

Immediate problems are those associated with the safety of the public and the handling of traffic. Traffic should be disrupted as little as possible and separated from the work with a temporary barrier railing located in such a manner that public protection is provided. It is normally preferable to do as much of the work as possible prior to the removal of the existing curb and railing. Temporary road widths and details for the temporary barrier railing should be shown on the plans. When detours are not available during construction; efforts should be made to move traffic at least one lane away from the widening, during concrete placement in the deck, particularly for structural steel girder widenings.

Negotiations for handling traffic, both on and below the structure, should be commenced with the District as early as possible. See Memo to Designers 21-19 for more detailed instructions on clearance needs and communications with the District.

4. Girder Type Selection

Generally in selecting the type of girder for a structure widening, the following considerations are involved: type of original structure, available space for falsework, relative economy, comparable live load deflection, and effect of construction on traffic. After taking all of these factors into account, some typical solutions might be as follows:

a) Widening a T-beam structure with a precast I-section.
b) Widening a steel structure with another steel girder or precast I-girder.
c) Widening a box girder structure with a precast inverted-T or hollow box girder. Parallel box girder structures may have the median decked, utilizing precast I- girders.

These solutions should be considered in addition to cast-in-place construction, to minimize the amount of falsework required and its effects on traffic.

If the above solutions are not feasible for a single span structure, consider widening with a prestressed, cast-in-place box girder constructed on falsework above final grade. After prestressing, the structure is lowered to grade and the closure is placed.

5. Longitudinal Joints

Past performance indicates that longitudinal expansion joints between a widening and an existing bridge have been the greatest single source of bridge maintenance problems. Therefore, as a general policy, widenings are to be attached to the existing structure without longitudinal expansion joints. Necessity for special attention to the attachment detail cannot be overstressed. The following recommendations should be followed when widening an existing structure.

a) Structures with large overhangs should be attached by removing the concrete from the overhang. There should be sufficient width to develop adequate bond length when lapping the original transverse deck reinforcing to that of the widening.
b) Structures with small overhangs, where removal of the overhang would not give sufficient bond length, should be either doweled to the widening or have transverse reinforcing exposed and extended by welding or mechanical lap splice.
c) Structures with no overhangs should be attached by doweling the existing structure to the widening. Double row patterns for the dowels perform better than a single row. Benching into the existing exterior girder as a means of support has proven to be unsatisfactory.

When doweling reinforcing into existing concrete, two methods can be utilized: drill and grout dowels or drill and bond dowels. For drill and grout, a neat cement paste is specified for the bonding agent. This method requires a sloped hole, at least 3 to 1, so the fluid grout will not escape. For drill and bond, a magnesium phosphate concrete is specified for the bonding agent.

See *current* Memo to Designers 21-41 for discussion of doweling methods (or future *Bridge Design Aids*, page 5-80).

6. Dead Load Deflection

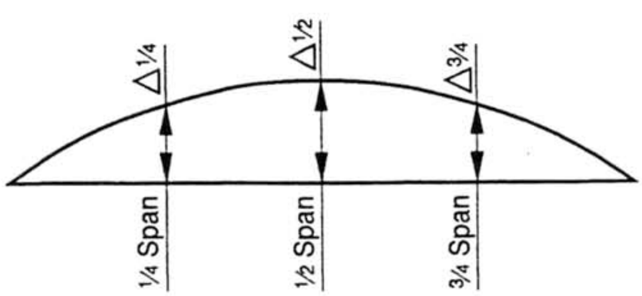
Two important facts must be recognized when considering dead load deflection, namely: the widening must initially be built above the grade of the existing structure to allow for dead load deflection, and the deflected widening must meet the grade of the existing structure. If proper provisions are not made to accommodate the dead load deflection, maintenance and construction problems will ensue.

To minimize maintenance problems, it is recommended that when the dead load deflection exceeds ¼", the main portion of the widening be allowed to deflect and a closure pour utilized to complete the attachment to the existing structure.

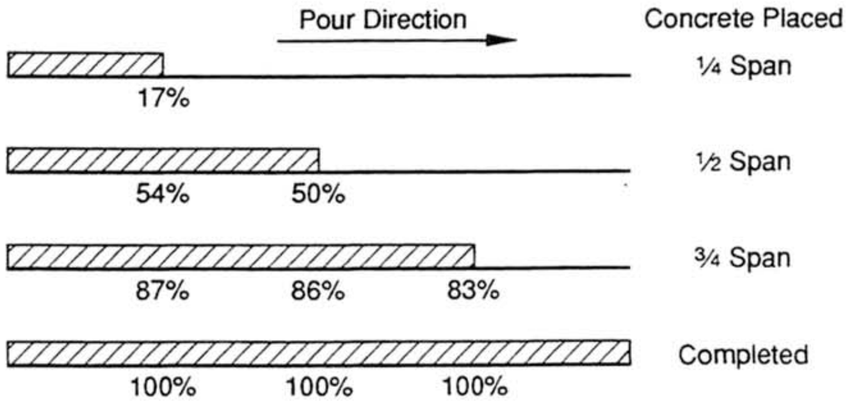
Dead load deflection can be placed into two groups: Precast or steel girder construction where the largest percentage of girder deflection occurs when the deck concrete is placed and cast-in-place construction, where the deflection occurs after the falsework is released.

Precast or Steel Girder

The following sketches show the different stages of precast or steel girder deflection as the deck concrete is placed from one end of the girder to the other. Analysis of these sketches illustrates the importance of using a closure pour such that the grade of the widening will match that of the existing. For example, if the calculated camber for a structure is 2" at mid-span and 1½" at ¼ span, when the deck has been placed for ¼ of the span, ⅜" of the 1½" ultimate camber at ¼ span will have deflected. A few hours later, when the girder has been completely loaded, the remaining 1⅛" of deflection will have occurred. In this case, a closure pour serves two useful purposes: It defers final connection to the existing structure until after the deflection from the deck slab weight has occurred; and it provides width to make a smooth transition between differences in final grades that result from design or construction imperfections.



Dead Load Camber Diagram



Percentage of Dead Load Deflection

Cast-In-Place Construction

For cast-in-place structures, the dead load deflection continues after the falsework is released. The amount of deflection is of most concern in conventionally reinforced concrete structures, where approximately ⅔ to ¾ of the total deflection occurs over a 4-year period after the falsework is released. A theoretical analysis of differential deflection that occurs between the new and existing after closure will usually show that it is difficult to design for this condition. Past performance indicates, however, that the theoretical overstress in the connection reinforcing has not been a maintenance problem, and it is generally assumed that the additional load is distributed to the original structure with no difficulty or dissipated by plastic relaxation. Good engineering practice dictates that the closure width should relate to the amount of dead load deflection that occurs after the closure is placed. A closure width of 1'-6" minimum is recommended.

Total deflection can be minimized by using prestressed girders and a balanced design where P_e equals the dead load moment of the girder and deck slab and P/A equals the live load moment stress. This will require an increase in prestress force beyond that required for dead load plus live load. Also, it is advantageous to delay the placing of the closure pour to reduce the transfer of load to the existing structure, to improve the riding quality of the deck, to lower the stresses in the closure slab and to allow for shortening of prestressed girders.

When the widening is constructed on falsework over traffic, it is desirable to remove the falsework as soon as possible to minimize the hazard to public traffic. In this case, the structure should be allowed to deflect for a long period of time before placing the closure pour. The following note should be placed on the plans:

> "Falsework shall be removed as soon as permitted by the specifications. Closure pour shall not be placed sooner than 60 days after the falsework has been released."

When falsework for a widening is not a hazard to traffic, the same overall results can be obtained in a shorter time by delaying the release of the falsework. If this is feasible, the Contractor should be given an option, and the following notes placed on the plans:

Falsework Release

Alternative 1:

Falsework shall be released as soon as permitted by the specifications. Closure pour shall not be placed sooner than 60 days after the falsework has been released.

Alternative 2:

Falsework shall not be released less than 28 days after the last concrete has been placed. Closure pour shall not be placed sooner than 14 days after the falsework has been released.

When Falsework Release Alternative 2 is used, camber values are 0.75 times those shown.

The falsework release note is on Decal No. 33.

7. Earthquake Standards for Widenings

When preparing Advanced Planning Studies, General Plan Estimates, etc., for widenings, the District should be consulted as to the need and costs to upgrade the structure for seismic resistance as soon as possible.

Discussion

Bridges that are to be widened should be upgraded as closely as practicable to the current seismic safety standards. While performing the work for a bridge widening, the designer must not limit the investigation for seismic improvements only to bridges which were originally identified for retrofitting. The widening may change the seismic behavior of the entire structure and require it to be upgraded. The extent of and the methods of upgrading will vary with each individual structure, depending upon the location, amount of widening, and type of widening.

When developing bridge widening plans, the designer is responsible for analyzing seismic behavior and providing coordinated seismic resistant features for the entire structure. Unfortunately, there are no specific guidelines to offer the designer, since each bridge type and site will present a unique situation. However, the prerequisite to any successful design is an analytical, logical approach which considers all the factors involved. The designers should consult with the Seismic Analysis and Structural Analysis (SASA) section for conceptual recommendations. When a widening project is assigned; the need for seismic retrofit should be determined. If recommended by SASA, combine the seismic retrofit with the widening effort. The seismic status of the bridge can be obtained from the Earthquake Engineering Unit. If a retrofit is planned, a formal request to SASA must be made to remove the structure from the retrofit list.

The designer should also investigate the possibility of approach slab failure/settlement and consider retrofit of this feature when necessary.

Following the analysis of bridges in modification projects for seismic needs, the designer will arrange for a strategy meeting similar to those held for pure reftrofit projects. At this meeting it will be determined the extent of reftrofit required to meet the seismic safety criteria, no collapse, no major damage and additional concern for structures identified as crucial to emergency response in a civil disaster.

Plans, schedules and estimates will be prepared on the basis of the strategy meeting determinations.

Widened structures will generally fall into three categories:

Category I: Widened Portion Resists Seismic Forces for the Entire Structure

The columns and footings of many existing bridges do not conform to our present earthquake design criteria. As it is usually impractical to rebuild or upgrade these original components, they do have some nominal lateral capacity and consideration should be given to designing the abutment keys of the widening to resist additional longitudinal and transverse forces for the entire unit, thus relieving the existing columns.

When the bridge is to be widened on both sides and the added width is approximately equal to the deck width of the original structure, it is desirable to design the earthquake restraining devices in the widened portion to accommodate the forces from the entire completed unit. This approach presumes that the widening can be adequately attached to the existing structure. Hinge restrainers and shear keys should be designed to receive loads from the entire structure. However, the new columns may be designed to carry loads in combination with the existing columns. In the combined condition, the designer must arrive at a rational method to proportion the loads appropriately to both the new and existing columns.

Category II: Widened Portion and Original Structure in Combination Resist the Seismic Forces

When the proposed widening is primarily on one side only, or when Category I requirements are difficult to meet, the restraining devices may be added to the original as well as the widening. These devices should be compatible with each other.

Following are a few examples of potentially incompatible seismic details:

a) Slender, non ductile pile extensions supporting an existing bridge and ductile columns supporting the widening.
b) Rocker bearing supporting the existing bridge and elastomeric pad bearing supporting the widening.
c) A large gap between the superstructure and seat abutment backwall on an existing bridge, and no gap for the widening.

The above list of examples is far from complete. As stated above, features are only potentially incompatible. A short bridge with no skew in a low seismic area could have a large mix of differing features and remain seismically sound. As a bridge lengthens, skews increase, and seismic levels rise, those differences will pose major problems.

There are a number of solutions to the problem of incompatibility between the new and existing structure:

a) Provide the widened portion with pier walls to resist seismic forces.
b) Provide raised seats adjacent to rocker bearing to prevent a sudden drop of the existing structure relative to the widening or remove and replace the rocker bearing with elastomeric bearings.
c) Provide blocking in the abutment gap of the existing structure so the new and existing move together.

Whether the structure types are the same or different, the original structure has been retrofitted or not, and/or the age of the structure is pre or post-1971 (San Fernando), the designer must assure that the seismic behavior of the widened portion is complementary with the existing structure.

Category III: Original Structure Resists the Seismic Forces for the Entire Structure

In the case where the original structure meets current design standards or has been retrofitted, the widened structure should not be assumed to be seismically adequate. Any amount of additional mass may affect its behavior. For example, when sliver widenings (less than one lane) are used, the original structure should be analyzed for seismic stability. Typical solutions consists of adding restraint, increasing seat widths to accommodate movement or a combination of the two.

8. Existing Deck Overhangs

The quality of concrete beneath the curb and railing in existing deck overhangs maybe of questionable value due to the rough finishing and the damage done in removing the curb and railing. In some cases, particularly in structures with small or no overhang, the concrete beneath the curb and railing by necessity must remain and the surface refinished. The specifications dictate the procedure for refinishing bridge decks, so only the limits of deck refinishing are required to be shown on the plans. When the concrete under the curb and railing is to be removed to expose sufficient bond length of reinforcing, show only the limits of concrete removal. *Standard Specifications*, Section 15-4.02, "Removal Methods," defines the procedure for concrete removal. As a general rule omit all reference to saw cuts in the plans. Simply delineate and identify the limit of concrete removal. If other than the specified one-inch cut depth is desired, request a changed dimension in the special provisions by means of a memo to the Specifications Engineer.

Some slab structures were originally designed for a future widening by providing 4 – #10 bars near the edge of deck. For these slab structures it is recommended that the concrete under the curb and railing remain and the widening be attached to the existing structure by using a double row of dowels.

9. Live Load Deflection

All structures deflect when subjected to live loading and many bridge widenings are constructed with traffic on the existing structure. Fresh concrete in the widening, and later in the deck closure, is sensitive to deflections and vibrations caused by traffic. This can result in loss of bond between concrete and reinforcing steel. The deflection can be a particular problem with steel girder structures where the live load deflection is large compared to cast-in-place construction.

Designers should work with the district to determine if, when, and how long traffic could be diverted to minimize vibration of a closure pour. If the time available is a matter of days Class A PCC would be satisfactory. If the vibration-free time is a matter of hours, we should consider "Set 45" concrete or similar early strength product for the closure pour.

To minimize these effects when traffic is anticipated, statements similar to the following should be included in the special provisions:

a) During placement of deck concrete, except that in the deck closure, reinforcing steel protruding from the new deck into the closure space shall be completely free of contact with the existing structure. Contact with existing reinforcing steel or concrete or attachments thereto, including forms, shall not be permitted.
b) During placement of deck closure concrete, the new and existing transverse reinforcing steel within the closure shall be securely connected together or to common longitudinal reinforcement.
c) Forms for the deck closure pour shall be supported from the superstructure on both sides of the closure space, unless otherwise directed by the Engineer. A standard special provision is available for this purpose. It should be requested by means of a memo to the Specifications Engineer.

The live load deflection of the widening must be compatible with that of the existing structure or these movements usually result in a spalled deck at the connection. To minimize these effects for steel structures when traffic is anticipated during construction, flexibility must be retained in the closure slab with the closures as wide and thin as possible.

10. Substructure

An existing structure will ordinarily not be subjected to any settlement of its footings by the time the widening is done. Pile capacities of existing structures should be checked by Translab Engineering Geology if additional loads are to be imposed on them by the widening. It is possible, for footings under a widened portion of a structure to settle. Suitable provisions should be made to prevent possible damage when such movements are anticipated.

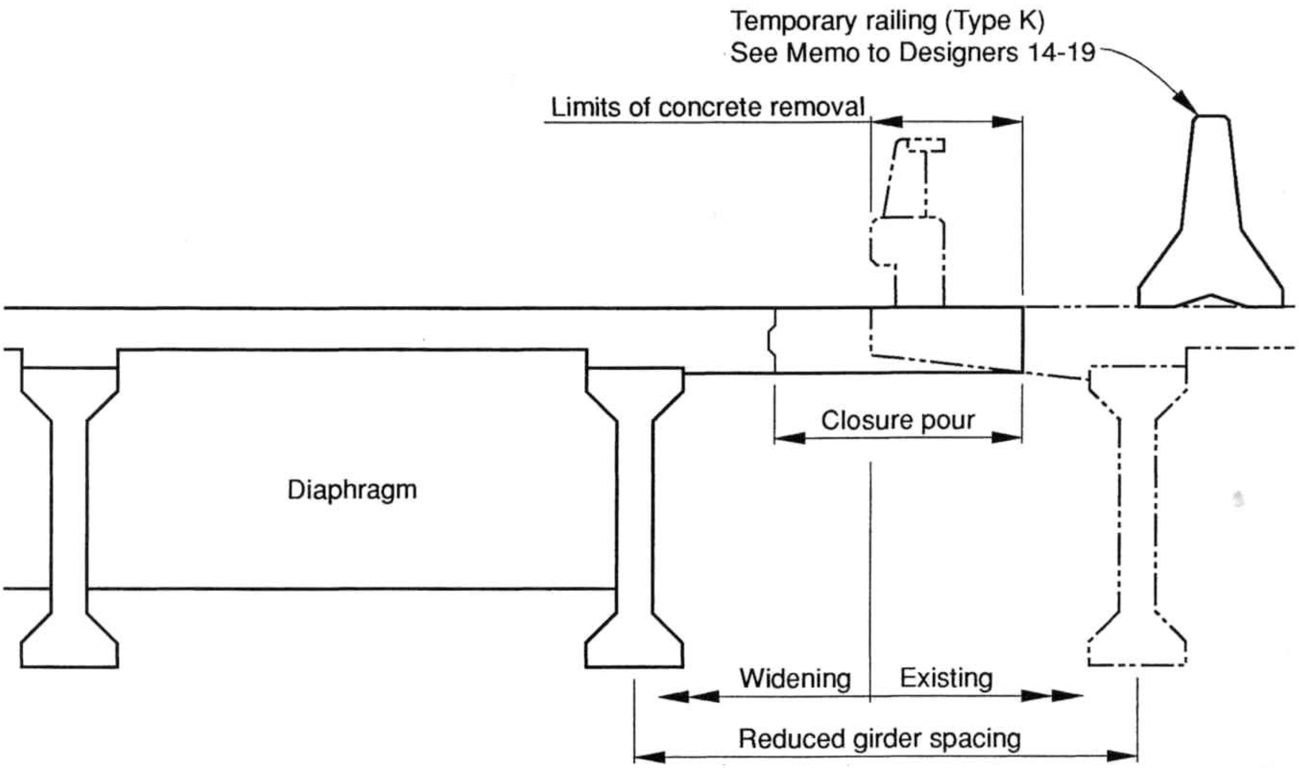
Generally, for cast-in-place structures, the bent caps should not be attached unless structurally beneficial to the bridge, such as for seismic considerations. Abutment diaphragms should be attached by doweling into the existing diaphragms. For prestressed widenings, the abutment diaphragm, pier walls or other rigid connections should not be attached initially until the structure has shortened and then a closure pour should be used to complete the attachment to the existing structure.

11. Details

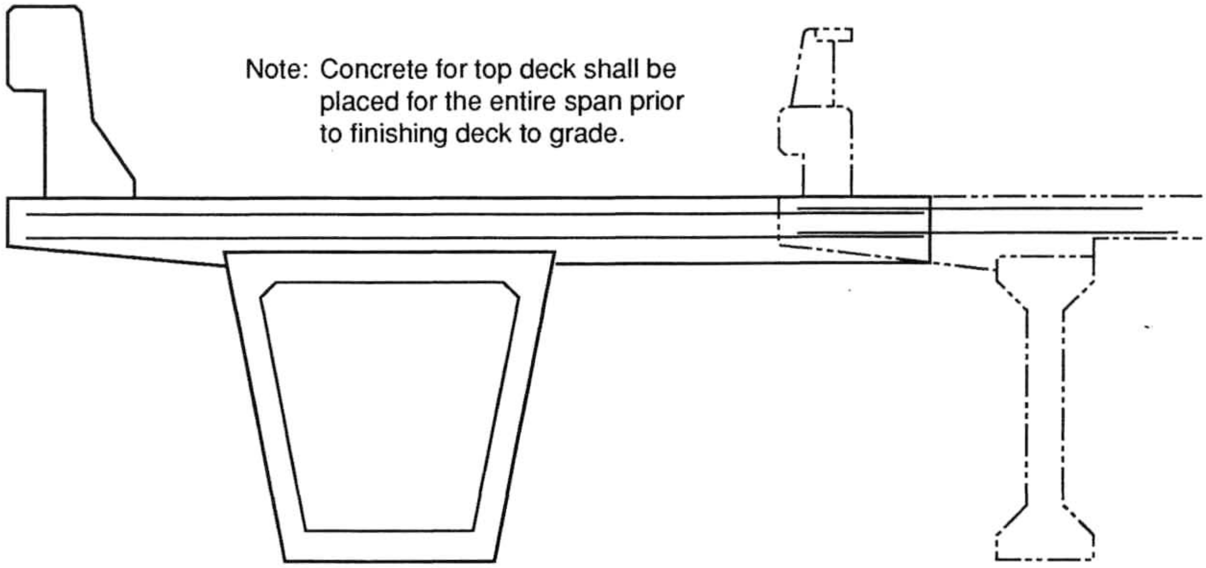
The following sketches illustrate some preferred details which have given satisfactory results. Since each widening job usually represents a unique situation, these details are offered as ideas rather than as completed solutions for every problem.

Experience has shown that positive attachment of the widened and original decks by lapping reinforcing steel provides a better riding deck, is usually better appearing and reduces maintenance problems. It is recommended that a positive attachment of the old and the new decks be made for the entire length of the structure.

Widening Precast Prestressed Girder Bridges

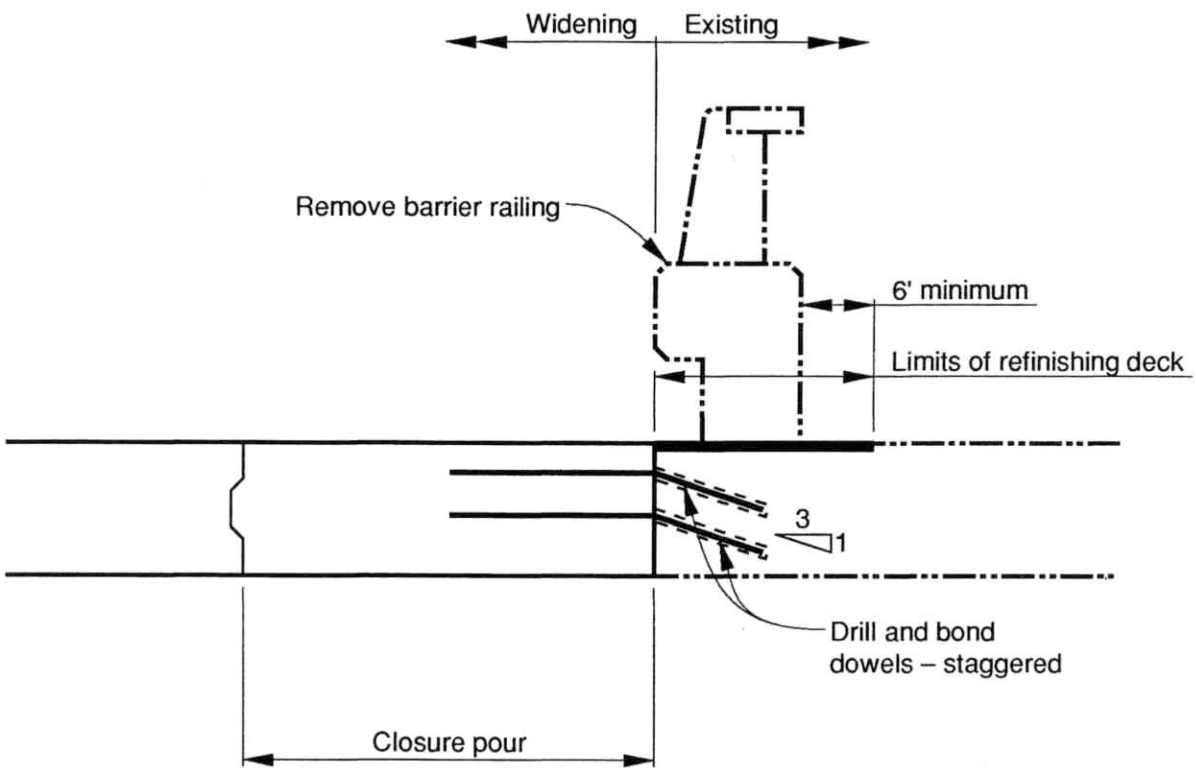


Multi-Girder Widening

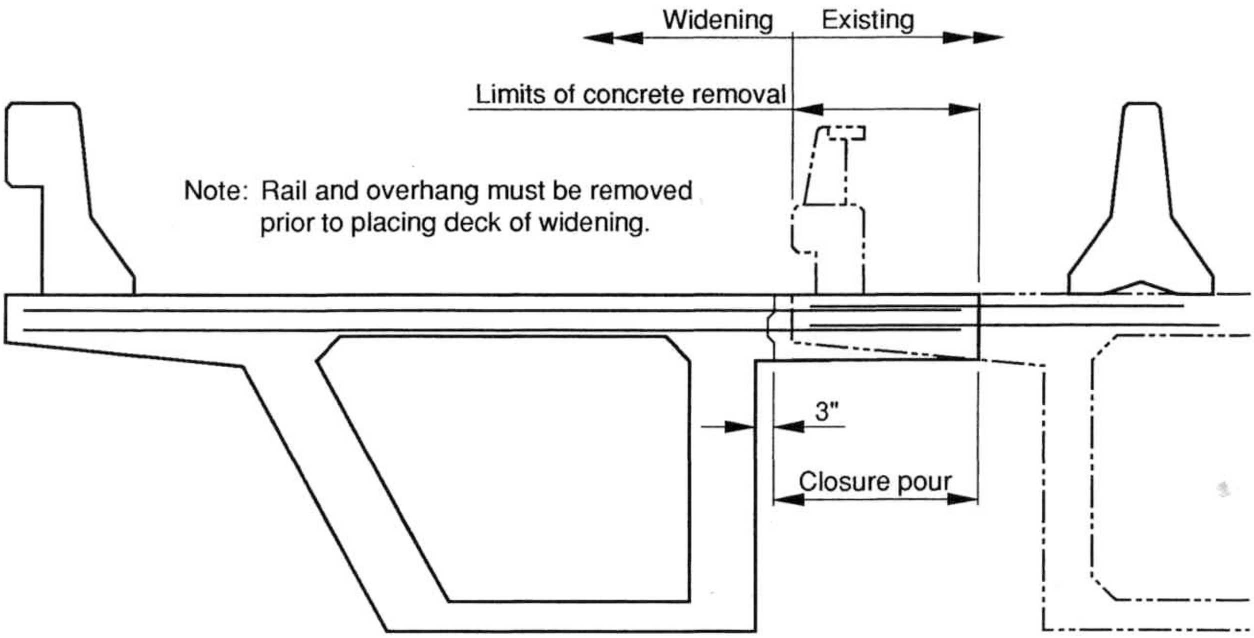


Single Girder Widening

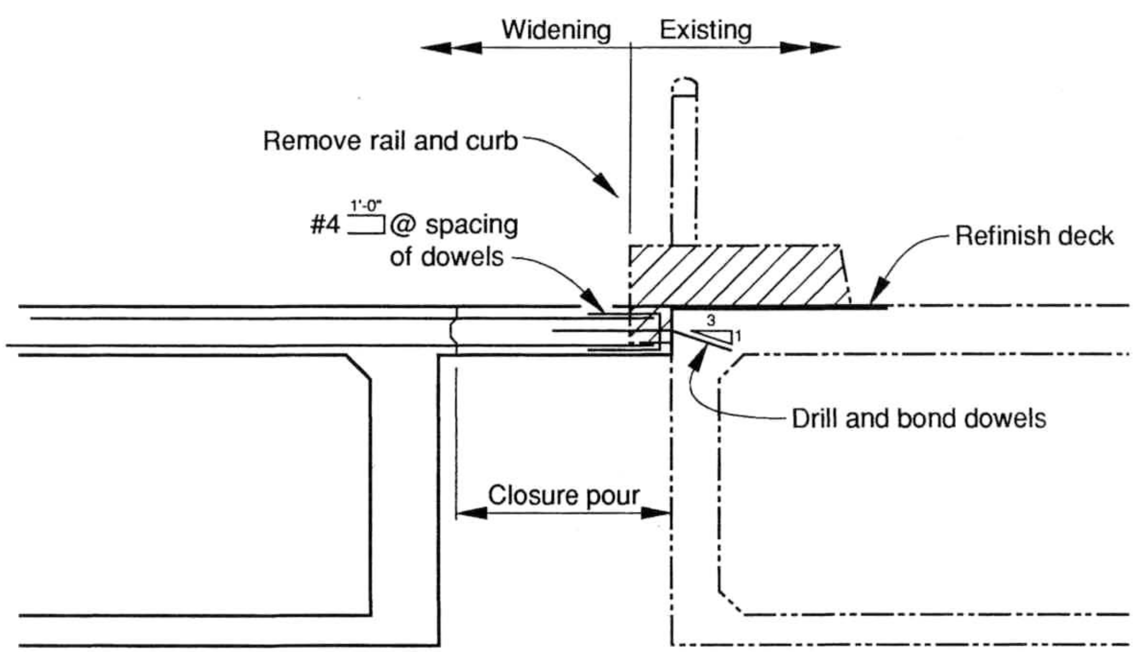
Widening Slab Bridges



Widening Cast-In-Place Bridges

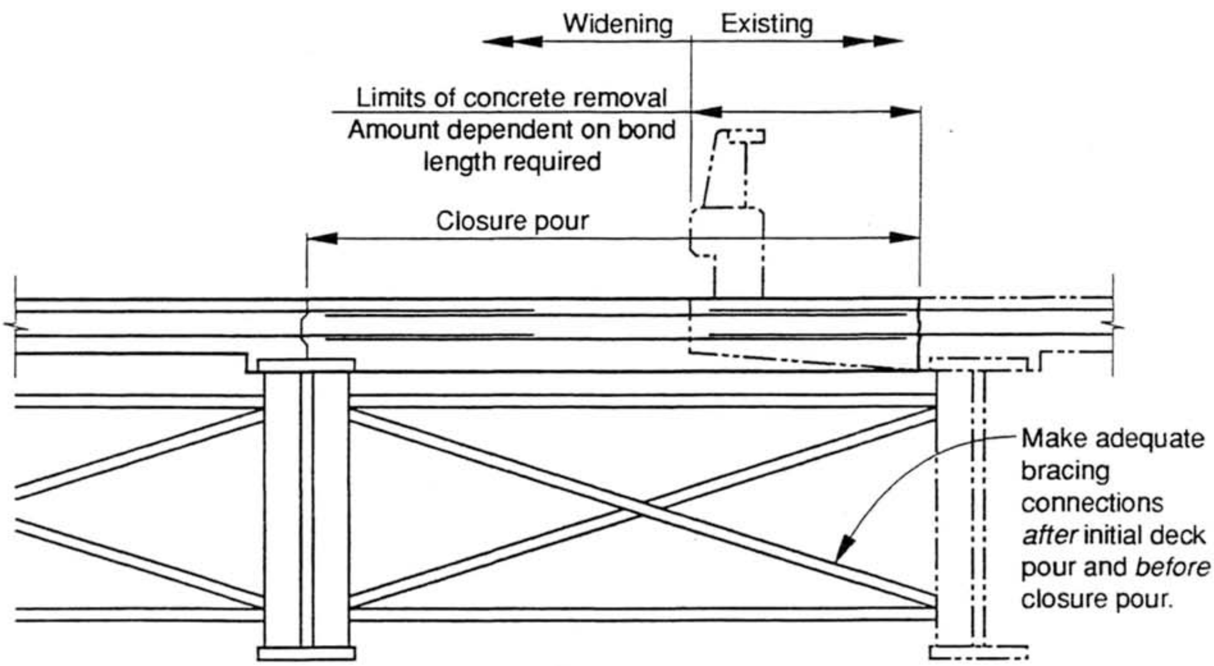


With Deck Overhang

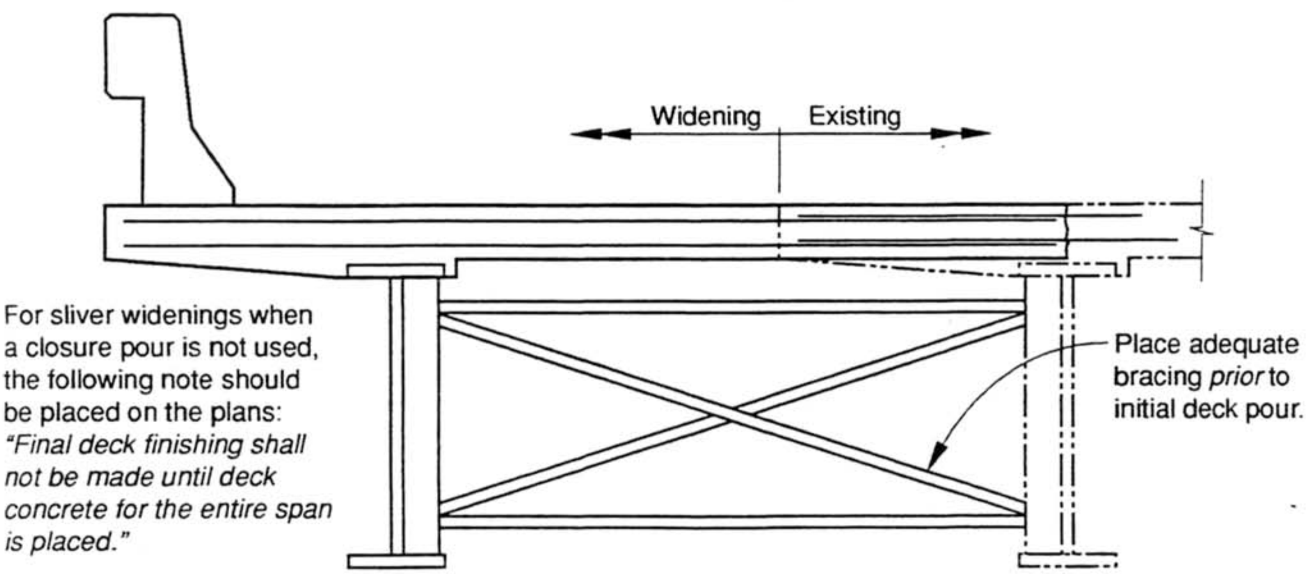


Without Deck Overhang

Widening Steel Girder Bridges



With Closure Pour (Multi-girder)



Without Closure Pour (Single Girder)

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